

Inter-firm R&D partnerships-major theories and trends since 1960

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Chapter 21

Interfirm R&D Partnerships: Major Theories and Trends since 1960

John Hagedoorn and Richard N. Osborn

This paper explores forty years of data on R&D partnerships in light of popular theoretical perspectives developed to explain interfirm cooperation. In comparison to the theoretical perspectives the historical data suggest the following three themes: (a) there is a theory lag where interfirm R&D partnering was theoretically neglected until well after the rise of this form of cooperation, (b) there needs to be a shift in theoretical expectations reflecting the historical shift from joint ventures to non-equity cooperation, and (c) there is a new theoretical challenge from the shifting concentrations of formation in different industry sectors.

Introduction

This paper focuses on rise of collaborations between independent companies through formal agreements, such as contractual agreements and joint ventures. Although companies can cooperate in many activities, we will look at partnerships where R&D is at least part of the collaborative effort simply because these cooperations have reflected and promoted two of the most fundamental competitive shifts of the last half of the twentieth century, i.e., technological development and globalization.

While existing theory in the 1960–1980 period generally ignored these R&D partnerships, a number of key perspectives have evolved to understand these complex entities. Collectively, the literature recognizes the push and pull of (a) greed and guile for efficiency and expansion, and (b) sharing and shaping for

innovation and strategic advantage in advocating that alliances expand global opportunities, reduce transaction costs, facilitate organizational learning and enhance strategic implementation (see for instance Kogut, 1988; Contractor & Lorange, 1988; Osborn & Hagedoorn, 1997). We say these are perspectives simply because each highlights a different series of elements that compose the complex systems known as R&D partnership.

Unfortunately, most empirical studies on R&D partnerships and other forms of interfirm collaboration are often based on convenience samples, usually of a cross-sectional nature. In the 1980s a number of attempts were made to set up databases that would allow longitudinal research but the work on most of these databases was terminated after a number of years (e.g., Osborn & Baughn, 1995). Apart from some “commercial” databases, that are mainly focused on the biotechnology and information technology sectors, there are few databases that generate both cross-sectional and longitudinal insight for both domestic and international alliances (Hagedoorn, Link & Vonortas, 2000). The MERIT-CATI database is one of the few still existing databases and it will be explored in the following to discover a number of general trends and patterns in R&D partnering (see Appendix 21.1 for a description).

Perspectives for Examining Alliances

At the beginning of this century it is all but impossible to quickly review and categorize all of the relevant literature on alliances and networks. Just in the last five years there have numerous special issues such as those in the *Academy of Management Journal*, *Organization Sciences*, *Organization Studies*, and the *Strategic Management Journal*, just to name four journals. In addition to these special issues, journals are replete with conceptual and empirical analyses of cooperation. Many of these contributions seem to flow from four different overall perspectives that can be labeled multinationalization, transaction cost economics (TCE), interorganizational theory and strategic management.

Multinationalization and Transaction Costs

It is convenient to begin with a multinationalization perspective. As our study period opens in 1960, David Lilienthal is said to be the first scholar to use the term multinational to describe the fundamental changes in cross-border business transactions occurring after WWII (see Robock & Simmons, 1973). Trade was increasingly internalized with the rise of corporations with operations in

numerous nations operating under a single integrated hierarchy. During the 1970s a whole series of economic based theories emerged to explain how and why these institutions were becoming the dominant organizing form spreading throughout the globe.

The spread was attributed to a firm's attempt to extend a product's life cycle (Vernon, 1966), market imperfections within specific industries and sectors (Caves, 1971) and the related view to imperfections of internalization stressing the multinationals' internal competitive advantages over market exchanges (see Buckley & Casson, 1976). To these market imperfections and internal advantages, Dunning (1981), in his eclectic theory of international production, added locational factors. Within each of these theories, alliances (joint ventures) were but a by-product of the expansion of the multinational as it attempted to spread.

Initially, most of the advantages and costs of multinationalization were related to the production function of the firm. Only as the decade of the 1980s dawned did "transactions costs" fully enter the picture as the basis for weighing costs and benefits (e.g., Rugman, 1980). As a transaction cost perspective was incorporated there was a subtle shift from why and where multinational would expand to isolating the boundaries of these institutions both functionally and geographically. What was to be kept inside, what was to be purchased and what was to be placed in some sort of hybrid cooperation? When examining what was to be cooperated, the underlying emphasis on greed and guile (opportunism) to minimize costs seemed to eliminate the joint search for new knowledge.

Interorganizational Views

Totally unrelated to these lines of economic research was the work on interorganization theory. With the spread of an open-systems view of firms pervading organizational analysis (see Osborn, Hunt & Jauch, 1980 for a review) numerous scholars were investigating the linkages between and among firms (for a review of the early literature, see Neghandi, 1980). Interestingly, the key categories mirrored those found in the multinationalization and transaction cost perspectives but with entirely different conceptual boundaries and causal mechanisms. Organizations were at the center of both perspectives. Yet, with an interorganizational view these organizations were assumed to be complex systems with multiple, partially conflicting goals where all firms needed to cooperate and compete. Similar to a multinationalization perspective, many analyses examined the interplay among organizational, interorganizational (forms of cooperation) and larger setting factors (societal and locational factors) but the interorganizational view stressed simultaneous choice. Since many of the organizations

studied by these scholars were not privately held economic systems, resolution of the cooperate–compete paradox did not revolve around ownership (e.g. purchase, merger–acquisition and/or joint venture solutions) for cost minimization. Instead, the notion of social and political reciprocity for mutual gain toward shared larger goals gained prominence. Interestingly, one of the more prominent outcomes of cooperation was to be innovation so that cooperating parties would all benefit.

This perspective seems ideally suited to analyze R&D alliance formations among firms. However, most scholars focused on domestic social service organizations (see Neghandi, 1980). Thus, until the late 1980s this perspective was rarely applied to corporate alliances. (For some exceptions in the Contractor and Lorange, 1988 volume, see Lyles, 1988; Walker, 1988; and Westney, 1988.) Multinationalism and TCE were clearly the dominant perspectives.

So by 1980 the foundations for examining domestic and international R&D partnership were securely rooted in non-complementary literatures. While one set emphasized the importance of globalization and costs, it ignored the role of knowledge development and sharing, and vice versa. In all of this, it remains interesting to see what the actual formation patterns in these R&D partnerships were like. And also, if there was a growth in these R&D partnerships, was the academic literature behind or ahead of the “real” phenomenon?

General Patterns in the Formation of R&D Partnerships

It turns out that the overall pattern for new R&D partnerships is one of slow growth followed by a rapid acceleration starting in the late seventies and continuing throughout most the 1980s and 1990s (see Figure 21.1). This pattern is consistent with previous research on alliance formations (Chesnais, 1988; Hergert & Morris, 1988; Hladik, 1985; Mariti & Smiley, 1983; OECD, 1986, 1992).

During the 1960s the number of yearly established R&D partnerships, found in the MERIT-CATI database, remained at a very low level of between a couple of partnerships to around ten. At the end of 1960s and early 1970s there were about thirty of these partnerships established each year, while this rose to about fifty by the mid-1970s. Already these relatively small numbers attracted some attention in the literature because, as mentioned by Hladik (1985), this phenomenon puzzled academic observers. Given the dominant theories at the time, such was to be expected.

Toward the end of the 1970s there is a sudden increase to nearly one hundred and sixty new R&D partnerships. This phenomenon appears to be taken to a next

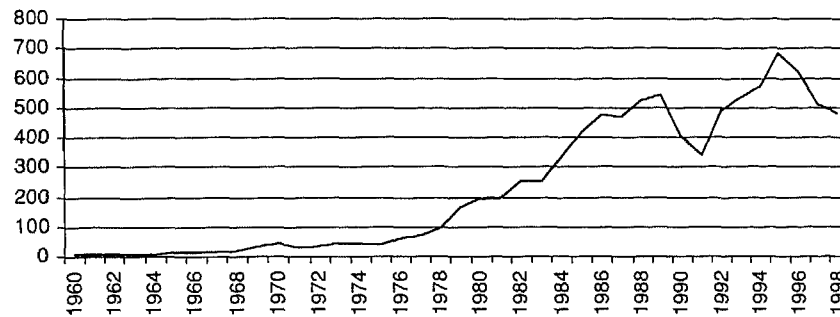


Figure 21.1: The growth of newly established R&D partnerships (1960–1998).

level during the 1980s. Those years mark a steep increase from about two hundred annually made partnerships to over five hundred new R&D partnerships made each year at the end of the 1980s and the turn of the decade. The first couple of years of the 1990s show a drop in the newly made partnerships to about three hundred and fifty and four hundred, but in 1995 there is another peak with a record of nearly seven hundred new R&D partnerships. Toward the end of the 40-year study period the number of new R&D partnerships is decreasing again, to about five hundred new partnerships. However, this number is still considerably higher than the figures found for most years since the early 1980s.

Clearly, the dramatic increase in the sheer number of R&D partnership during the late 1970s and throughout the 1980s was unanticipated in the literature. The natural reaction was to presume that firms were “forced” to collaborate on R&D due to the increased complexity of scientific and technological development, higher uncertainty surrounding R&D, increasing costs of R&D projects, and shortened innovation cycles that favor collaboration (Contractor & Lorange, 1988; Dussauge & Garrette, 1999; Hagedoorn 1993, 1996; Mowery, 1988; Mytelka, 1991; Nooteboom, 1999; OECD, 1992). Many scholars, however, did not challenge the theoretical veracity of the more dominant multinationalization and transaction cost perspectives even as they clearly challenged its implicitly assumed condition of stability in technology development.

A Strategic View and Patterns of Administrative Forms

As the number of new R&D partnerships was accelerating, a comparatively new strategic approach was applied to alliances (see Link and Bauer, 1989, for an

early review). This view attempted to explain the raft of “strategic” purposes for and potential outcomes from alliances in light of the strategic objectives of the partners, their similarity (e.g. size, strategy and bargaining power) and the competitive dynamics of specific industries (e.g., Harrigan, 1985). The early literature tended to regard R&D partnerships with substantial suspicion for two comparatively simple reasons. R&D was not often considered a sound and sustaining basis for a successful strategy and R&D partnerships were subject to piracy and bleed through (e.g., Harrigan, 1985). Yet, the introduction of this strategic perspective also automatically introduced an older notion from the strategy literature — that structure followed strategy (Chandler, 1962).

In the late 1980s and early 1990s a whole series of taxonomies arose to understand some of the more subtle differences among alliance forms (e.g., Auster, 1987; Chesnais, 1988; Contractor & Lorange, 1988; Hagedoorn, 1990; Osborn & Baughn, 1990; Yoshino and Rangan, 1995). Instead of hybrids, a variety of administrative forms were identified and differentiated. In regard to technology-related partnerships the more common forms include (a) licensing and cross licensing, (b) second-sourcing and mutual second-sourcing, (c) co-production and co-makership agreements, joint R&D pacts and joint development agreements and, of course (d) joint ventures. Many of these forms include provisions for reciprocal product/knowledge flows in addition to stressing the cooperative search for new knowledge. And most are not hierarchical. These taxonomies suggest a switch in the administrative forms used for R&D partnerships. If one examines the mix of administrative forms for new R&D partnerships during the past four decades, this switch is confirmed as shown in Figure 21.2.

During the very first couple of years of the 1960s, when there were very few R&D partnerships, the share of R&D joint ventures in all R&D partnerships was subject to strong changes from year to year. However, with the increasing number of newly made R&D partnerships, a clear pattern emerges in the share of R&D joint ventures. Ignoring some small oscillations around an overall trend in Figure 21.2, there is a sharp decline from a 100 percent share in the mid-1960s to less than 10 percent in 1998. During the mid-1970s the share of R&D joint ventures was still at a level of about 70 percent, in the early 1980s this share reached slightly over 40 percent. After a “sudden” increase in the late 1980s, the downward trend reached a level of 20 percent during the first half of the 1990s until it arrived at a small share of less than 10 percent at the end of the decade.

These overall trends in interfirm R&D partnering do indicate two major developments. First, by and large, companies seem to increasingly prefer contractual partnerships to joint ventures. Second, the growth of newly made R&D partnerships since the early 1980s is largely caused by an overwhelming increase in the

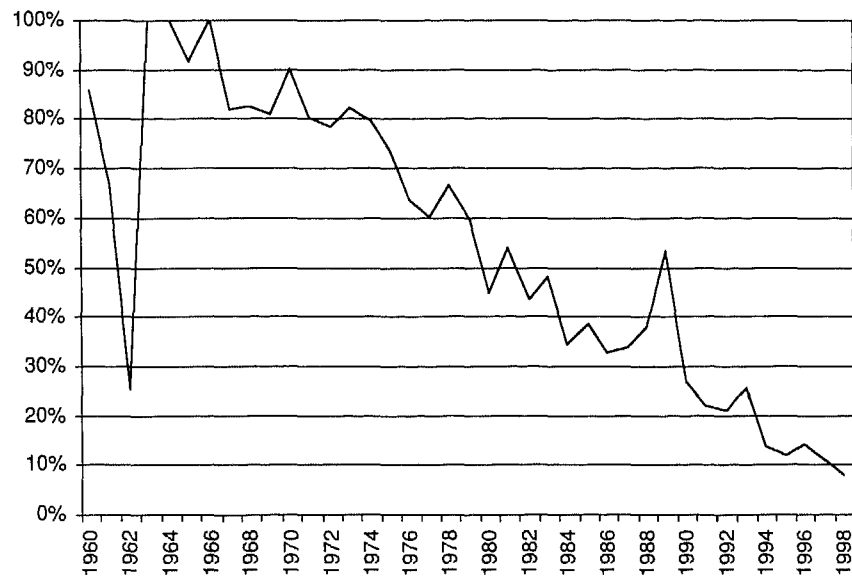


Figure 21.2: The share (%) of joint ventures in all newly-established R&D partnerships (1960–1998).

absolute numbers of contractual partnerships. Of course two important questions remain. Are these R&D partnerships concentrated in some sectors and are they part of a pattern of globalization?

Sectoral Patterns in R&D Partnerships

If corporate strategy is attuned to industry competitive conditions and the form of the alliance follows from corporate strategy then there should be a link between industry conditions and the form of the R&D partnership. Contributions by, amongst others, Ciborra (1991), Dussauge and Garrette (1999), Eisenhardt and Schoonhoven (1996), Harrigan and Newman (1990), and Oster (1992) suggest that interfirm partnerships are associated with so-called high-tech sectors and other sectors where innovation and flexibility are important features of the competitive landscape. These partnerships enable companies to learn from a variety of sources (partners) in a flexible setting of (temporary) alliances for various company activities across the value chain. Dussauge and Garrette (1999),

Hagedoorn (1993), Link and Bauer (1989), and Mytelka (1991) also indicate that many of these partnerships are concentrated in a limited number of, mainly R&D intensive, industries. As this paper concentrates on R&D partnerships, one can expect that, given the asymmetrical distribution of R&D efforts across industries, this particular group of partnerships will also be concentrated in R&D intensive industries.¹

Interestingly, Figure 21.3 demonstrates that the expected dominance of R&D partnering by high-tech (R&D intensive) industries has only gradually developed and did not become apparent until the mid-1980s. During the 1960s R&D partnerships in high-tech industries (pharmaceuticals, information technology sectors and aerospace and defense) counted for only between 20 and 40 percent of the overall number of newly made R&D partnerships. This was substantially lower than the share for medium-tech sectors (instrumentation and medical equipment, automotive, consumer electronics and chemicals) that on average accounted for over 50 percent of the newly made R&D partnerships in that early period. During the 1970s the share of high-tech industries varied between around 35 to about 50 percent, whereas the share for medium-tech industries during that same period by and large remained still close to 40 percent.

The 1980s and 1990s, however, mark a period where the growth of R&D intensive industries, influenced by biotechnology and a range of information technologies, is reflected in the increasing importance of these high-tech industries in R&D partnering. From 1980 to 1998 the share of high-tech industries in newly established R&D partnerships increased from about 50 percent to over 80 percent. During the same period the share of medium-tech industries in these new R&D partnerships decreased sharply from about 40 percent to less than 20 percent.

From a TCE perspective these patterns seems to present a challenge. Clearly the need for innovation represented by a high-tech sector is reflected in the choice of the more flexible collaborative contractual partnership forms, not in forms rooted in hierarchy. However, this apparent theoretical anomaly may be partially attributable to the intrusion of externalities such as the expected increase in international alliance formation expected from the multinationalization perspective.

Previous work by Freeman and Hagedoorn (1994), OECD (1992), Ohmae (1990), and Yoshino and Rangan (1995) has already revealed that the Triad

¹ Following the OECD (1997) sectoral R&D intensities (the share of total R&D expenses in total turnover) pharmaceuticals (including biotech), information technology and aerospace and defense are high-tech sectors with R&D intensities between 10 and 15 percent. Instrumentation and medical equipment, automotive, consumer electronics and chemicals are medium-tech industries with R&D intensities ranging between 3 and about 5 percent, other industries such as food and beverages, metals, oil and gas have a relatively low R&D intensity of below 1 percent.

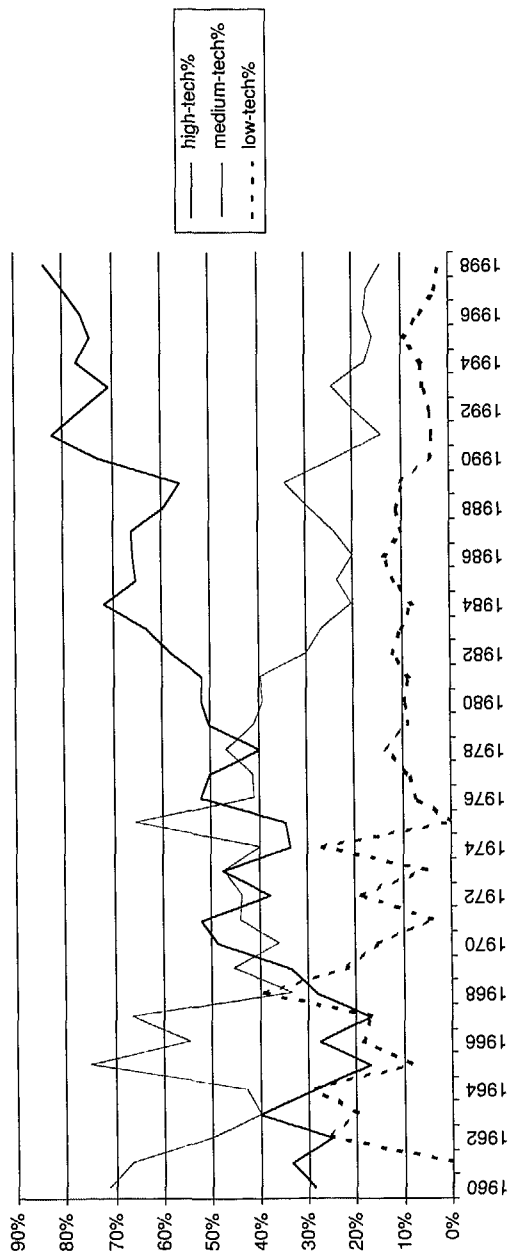


Figure 21.3: The share (%) of high-tech, medium-tech and low-tech industries in all newly established R&D partnerships (1960–1998).

(North America, Western Europe and Japan & Korea) dominates international interfirm partnering. Thus, we will examine domestic and foreign R&D partnership formations involving firms from these countries in the next section.

Domestic and International Patterns

Extending a traditional TCE perspective (Williamson, 1996) one would expect that companies would be hesitant to enter into R&D partnerships with foreign companies. This reluctance can be attributed to the lack of control in long-distance collaboration, the inability to enforce contracts across national boundaries, a lack of trust between companies from different countries and the high asset specificity of R&D. Conversely, with an interorganizational perspective national boundaries are rarely considered. In the globalization and strategy literature however, national boundaries play an important role alone and in combination with the expansion of multinationals.

In many contributions to the literature (Auster, 1987; Contractor & Lorange, 1988; de Woot, 1990; Dunning, 1993; Duysters & Hagedoorn, 1996; Hagedoorn & Narula, 1996; Mowery, 1988; Mytelka, 1991; Ohmae, 1990; Osborn & Baughn, 1990; Yoshino & Rangan, 1995) international partnerships or alliances are considered an important element in the international strategies of a growing number of companies. The basic argument in most of these contributions is that increased international competition between companies forces them to pursue international strategies. Through these international strategies companies not only seek foreign market entry but they also seek foreign assets (both of a tangible and an intangible nature) and build international interfirm partnerships for international sourcing of R&D, production and supply (Hagedoorn & Narula, 1996). Consequently, one could expect that, in the context of the overall importance of internationalization to companies and their partnerships, the share of international R&D partnerships in the total number of R&D partnerships should also have increased during the last four decades.

However, the past 40 years indicate a somewhat irregular and slightly downward trend in the share of international R&D partnerships (see Figure 21.4). During the 1960s and early 1970s, when there were only few of these partnerships, the share of international R&D partnerships dropped from an average of about 75 percent to close to 40 percent. During the mid-1970s the share rose again to nearly 80 percent, after which the trend gradually turned slightly downward from about 70 percent during the first years of the 1980s to about 60 percent during the early 1990's. The late 1990s end with a share of international partnerships below 50 percent of all newly made R&D partnerships.

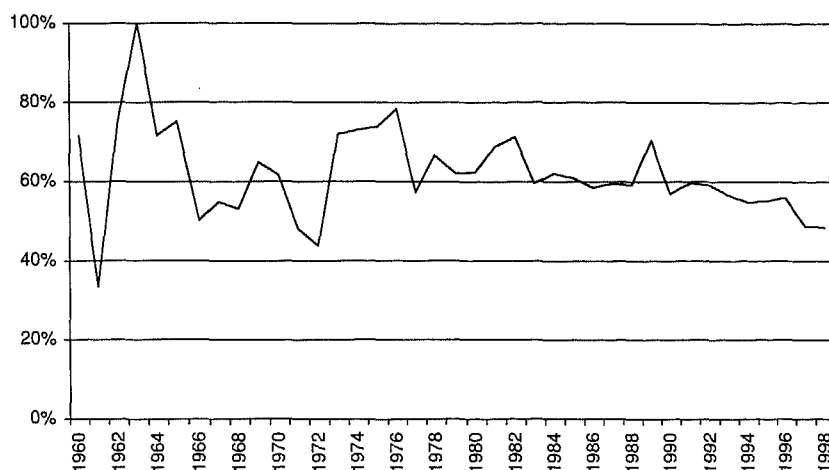


Figure 21.4: Share (%) of international partnerships in newly-established R&D partnerships (1960–1998).

For a further understanding of this development and the sectoral differences that might have occurred we calculated a simple “relative international partnering” index per sector.² This measure indicates the degree to which international R&D partnerships are more important in some sectors than in others. This index can be calculated by setting the ratio of international partnerships versus domestic ventures for each sector against the overall international partnerships/domestic partnerships ratio.

The relative international partnering indexes during the period 1960–1998 are 0.9 for high-tech industries, 1.5 for medium-tech industries and 0.85 for low-tech industries. Given this somewhat unclear pattern in international R&D partnering, we decided to take a closer look at the role that the different international economic and trading blocks play in all of this.

If one looks at the overall pattern in R&D partnering during the past four decades (see Figure 21.5), it becomes clear that North America (of which between 90–95 percent stands for US companies) clearly dominates the world of R&D partnering. Almost 70 percent of the R&D partnerships found for the

² The relative international partnering index (RII) is calculated per sector as the relative distribution of the sectoral number of international partnerships (IP_i) and sectoral domestic partnerships (DP_i) set against the distribution of all international partnerships (TIP) and all domestic partnerships (TDP): $RII_i = [IP_i/DP_i]/[TIP/TDP]$

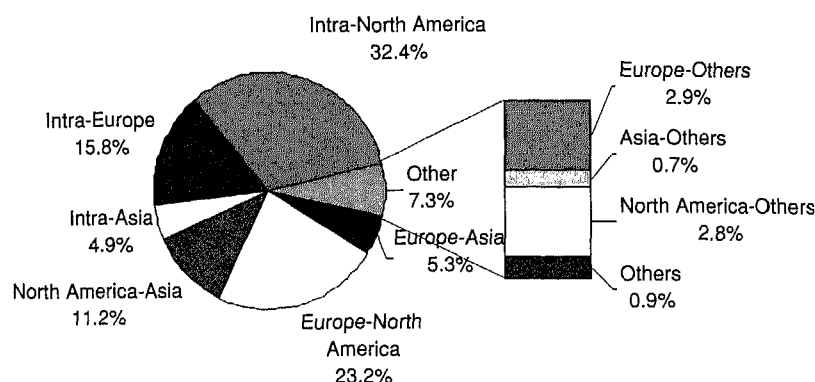


Figure 21.5: Distribution of R&D partnerships, economic regions (1960–1998).

past four decades had at least one North American partner. Partnerships within North America account for nearly a third of all the R&D partnerships. Nearly a quarter of the interfirm R&D partnerships are made between European and North American companies, which is substantially higher than the nearly 16 percent share found for intra-European R&D partnerships. R&D partnerships made between companies from North America and Japan and South Korea account for about 11 percent. Intra-Asian R&D partnerships and partnerships between Europe and Japan and South Korea remain at a relatively low level of about 5 percent.

Examining these patterns over time reveal some striking changes in the overall distribution of R&D partnerships since the 1960s. First of all it becomes clear that the important role of intra-North American partnerships is only a relatively recent development. During the 1960s and 1970s less than 20 percent of these R&D partnerships were established within North America (data available from the first author). Even in the 1980s less than a quarter of all R&D partnerships were made between two or more North American companies. However, the 1990s mark a sudden increase in the share of intra-North American R&D partnerships to over 41 percent. Second, the share of intra-European partnerships has gradually eroded from nearly 40 percent during the 1960s and 27 percent during the 1970s, to 19 percent during the 1980s and to only 11 percent during the most recent decade. Third, European-North American R&D partnering has gradually grown from about 16 percent during the 1960s to about 25 percent during the 1990s.

Additional analysis of these data reveals that the dominance of intra-North American R&D partnering is particularly strong in high-tech industries such as pharmaceuticals (biotechnology) and information technology. These sectors also represent a large share of the European-North American R&D partnerships. Grim as this picture might look it does parallel the current world-wide distribution of R&D resources and capabilities (Freeman & Hagedoorn, 1994). In that context the dominance of North America, particularly the US, also reflects the leading role that this continent plays in R&D and production in major high-tech industries such as the information technology sectors (computers, telecom, software, industrial automation, semiconductors) and pharmaceutical biotechnology (OECD, 1992). The growing importance of intra-US R&D partnerships also largely explains why international partnerships, despite a strong growth in absolute numbers, still take only about 50 percent of all R&D partnerships and why the trend toward a further internationalization appears to be stagnating.

Toward an Integrated View

Clearly the patterns of R&D partnership formation have changed dramatically over the years with alterations in administrative forms, involving different sectors each with a different mix of domestic and international R&D partnership. This is not a simple story of one perspective being clearly dominant over another. They are all partially correct and incorrect. We think a more careful theoretical synthesis can provide some new insight.

One way of synthesizing these views is to apply them as they stand to more fully understand the complexity of the cooperative systems used in R&D partnerships. For instance, legally joint ventures are organizational units created and controlled by two or more parent-companies (Berg, Duncan & Friedman, 1982; Hagedoorn, 1996; Hladik, 1985). From a globalization view these joint ventures might be seen as a step toward internalization. Using a TCE lens, joint ventures can also be seen as "hybrids," in between markets and hierarchies (Williamson, 1996). Yet, they do come close to hierarchical organizational structures, only the parent companies must share control over the joint venture. From an interorganizational perspective, joint ventures represent extremely high organizational interdependence between the parent companies. However, from a strategic perspective, joint ventures can also be seen as semi-independent systems. Joint ventures can perform standard company functions such as R&D, manufacturing, sales, marketing, etc. It is this semi-independent status that enables companies to apply joint ventures in a broader strategic setting where companies enter into

new markets, reposition themselves in existing markets or use exit strategies in declining markets (Harrigan, 1988).

By sequentially applying the various perspectives, it is also relatively easy to spot problems in R&D alliances. Again using joint ventures, scholars have identified the risk of sharing proprietary knowledge, the "appetite for control" by one partner and a variety of differences in strategic objectives (e.g. Dussauge & Garrette, 1999; Harrigan, 1985, 1988; Hladik, 1985; Nooteboom, 1999). Unfortunately, the sequential application may place too much emphasis on the intentions of a singular sponsor and too little light on the performance of the R&D partnership as a system. We contend that many of the identified problems of R&D partnerships are partially the result of a cooperative system's inability to deliver a success.

Administrative Form and Success

The dramatic increase in the popularity of contractual forms for R&D partnerships may be suggesting that these forms are a superior mechanism for accomplishing innovation in high-tech sectors. Specifically contractual agreements with reciprocal R&D sharing between two or more companies, such as joint research or joint development partnerships, appear particularly suited for innovative success. Such undertakings imply the sharing of resources, usually through project-based groups of engineers and scientists from each parent-company. The costs for capital investment, such as laboratories, office space, equipment, etc., are shared between the partners. Although these contractual R&D partnerships have a limited time-horizon, due to their project-based organization, each partnership appears to ask for a relatively strong commitment of companies and a solid interorganizational interdependence during the joint project. Of course, compared to joint ventures, the organizational dependence between companies in a contractual R&D partnership is more focused and the time-horizon of each separate project is, by definition, shorter than that of a joint venture (see Hagedoorn, 1993).

In high-tech industries such as biotechnology, pharmaceuticals and information technology sectors, these contractual arrangements can be and are frequently focused on in-depth research activities. In many other industries these partnerships will concentrate more on the development and engineering of new products or new processes than on research. The key to control of non-contractual collaborative efforts seems to rest on the continuation of technical success and reciprocity as well as the difficulty of easily transferring knowledge from one organization to another.

While it is possible to simply view these forms as “incomplete contracts” (a default form attributable to the impossibility of specifying the concrete results of the joint effort), such a view may understate the role of reciprocal knowledge flows and the indirect control that arises from potentially withholding knowledge. We contend that the use of a fluid, adaptive, decentralized and technically oriented form to cooperate is consistent with generating innovation in a highly dynamic complex technical setting with rapidly changing application of knowledge (Burns & Stalker, 1961). Conversely, joint ventures provide hierarchical control more suited to alliances where there are comparatively large capital stakes in industries with moderately changing technologies and where there is integration of R&D with other functions. Here, technical efficiency and transaction cost efficiencies may be more important for a successful alliance than innovation.

Configurations of R&D Partnerships

A second way of integrating the four traditional views is to consider mixed missions for R&D partnerships. Across all R&D partnerships it seems that both a cost-economizing rationale and an innovative rationale play a role in addition to the need to develop a form consistent with the competitive dynamics of the alliances’ setting. An easy way to examine the balance between these rationales is to take a strategic perspective.

The cost-economizing rationale applies when at least one company enters the partnership mainly to lower the cost of some of its R&D activities by sharing the costs with one or more other companies. This cost-economizing rationale appears to particularly play a role in capital and R&D intensive industries, such as the telecom capital goods industry, where the cost of single, large R&D projects are beyond the reach of many companies (see Hagedoorn, 1993). However, an innovative rationale appears to loom large if, for instance, companies decide to selectively enter into R&D partnerships that are not related to their core activities while keeping their main R&D activities within their own domain (Teece, 1986). The innovative strategic intent of R&D partnerships is also apparent in those cases where companies jointly perform R&D in new, high-risk areas where the future importance for their technological capabilities remains unclear for a considerable period of time.

For many R&D partnerships cost-economizing, innovative and other self-interested motives are probably intertwined. This becomes most apparent if one looks at the results of some studies on motives for interfirm partnerships. Most studies on R&D partnerships or similar forms of alliances (see, amongst others, Das, Sen & Sengupta, 1998; Eisenhardt & Schoonhoven, 1996; Hagedoorn,

1993; Hagedoorn, Link & Vonortas, 2000; Lorenzoni & Lipparini, 1999; Mowery, Oxley & Silverman, 1998) stress a variety of major motives for these partnerships. In regard to costs these include: (a) achieving economies of scale and scope in R&D and (b) sharing the costs of R&D projects. In regard to innovation these include: (a) the need to monitor and engage in the cross-fertilization of technological disciplines, (b) the search for technological synergies, (c) the need to incorporate complementary technologies, and (d) the need to shorten the innovation cycle and produce new products and processes for old and new markets. We would be remiss not to also mention motivations reflecting self interests to the help a firm (a) cope with technological uncertainty, (b) capture a partner's tacit knowledge (c) prevent competitors from gaining a technological advantage and (d) collectively establish an industry standard.

It is popular to believe that the strategic intent of the partners is translated to the alliance, remains unchanged, and becomes the alliance's strategy. We contend that where the intentions of the parties is mixed, the form of the alliance, its strategy and the types of success it provides, will evolve over time. For some firms developing effective R&D partnership may be important strategically and it may have very clear intentions for innovation or costs or another performance dimension. There is some evidence that leading companies (market leaders and technology leaders) seek partnerships outside their core activities, searching for new activities and new technological opportunities beyond their current domain (Hagedoorn, 1995; Hamel, 1991; Hamel & Prahalad, 1994). Here we would expect to find them administered as agreements and yielding innovation. Yet, with the vast number of R&D partnerships, it would be difficult to assume that each and every one was "strategic" or motivated by the firm's specific strategy. Instead the alliance's strategy is expected to be more generic and less focused for these leading firms. Instead of an alliance being strategic, it is the establishment of a portfolio of innovative alliances that is strategic.

Given the different motives for partnerships one can expect that for many companies the specific administrative form for any particular R&D partnership would then need to flow from the specific mix in intentions and the ability of the form to deliver a successful outcome. The more cost economizing (either in terms of production or transactions cost) dominates, the more likely a joint venture. If innovation dominates, the more likely the cooperation is formed as a joint R&D pact or a joint development agreement. However, if these intentions are balanced, the alliance is not strategic or there is another intention (coping with uncertainty or capturing tacit knowledge), the administrative form of the alliance most likely to yield the desired outcome is unspecified. While form is expected to follow from strategy, over time we also expect the reverse to be true as well. Over time an R&D partnership established with mixed motives relying

upon an administrative form designed for innovation may experience more innovation than cost reduction and evolve into one with an innovative strategy. If this is consistent with the competitive dynamics of its industry, it may well be continued.

With several initially mixed motive alliances with an administrative form consistent with a particular outcome, say innovation, the strategy of a sponsor may also shift to be more consistent with that of its alliances. Over time with many R&D partnerships, a sponsoring firm may also see its skills change. For instance, a firm's willingness and skill at using various administrative forms for cooperating R&D may evolve to the point that such arrangements are no longer novel but a way of conducting R&D.

We also suspect that the geographic boundary for innovatively oriented R&D partnerships will reflect the relative clustering of technical competency in specific nations (e.g., the US dominance in information technology versus the spread of technical competence in chemicals across the US and Europe). When capital intensity is important and R&D focuses more on processes in moderately intense R&D sectors, we can see the classic movement of dominant firms in one sector of the Triad moving abroad.

If current trends continue, new R&D partnerships will be mostly formed as contracts with intended reciprocal flows of knowledge to be focused on innovation where the formation reflects firm specific competencies. Internationally, the ebb and flow of new R&D partnerships will reflect the research competencies of firms in different nations. The more broadly based the knowledge, the more likely international R&D partnerships will be formed.

Toward the Future

Each of the four perspectives developed prior to 1980 seems to show the strain of radical developments in R&D partnerships over the last 10 to 15 years. Relentless globalization seems evident only in some sectors and not in the more glamorous high-tech sectors but the more mundane medium-tech ones. Transaction cost analyses still seems important, but only in some sectors without rapid technological change and where capital costs appear to loom large. Inter-organizational analysis appears salient for high tech, but seems to fail in explaining the pattern of R&D partnerships in medium and low tech sectors. That structure follows strategy only appears clear when the strategy seems to involve either cost minimization or innovation.

Even with the theory following the development of new R&D partnerships, considerable progress has been made. The theoretical units of analysis are now

much clearer, i.e., firms and their cooperations in their industry, national and regional settings. While the units appear to be the same, our understanding of the salient dimensions for each has rapidly expanded. For instance, alliances are not similar to "hybrids" but are a constellation of distinct forms. The causal mechanisms are now clearer, geographic expansion, minimizing production and transactions costs, facilitating learning and innovation and pursuing strategic interests will likely remain important driving forces used to explain and predict formation and success. It is now understood that none of these standing alone is sufficient.

To the four perspectives that we discussed in the above we have added the notion that the linkage between the administrative form of the alliance and its performance as a system is critical. The emphasis moves away from just the single motivation of a dominant firm. And we have suggested that over time the development of multiple R&D alliances may in turn alter a firm's strategic capabilities. These additions are moving us toward a theory of alliances, not a theory of trade, industrial economics, interorganizational theory or business strategy. Research related to such an innovative perspective might generate some new topics, such as those listed in Box 21.1.

First of all, we hope that in the future there will be more studies of R&D partnerships as cooperative systems. Effective cooperative systems might be expected to provide geographic scope, efficiency (reductions in production and transaction costs), innovation and/or legitimacy for its members and its investors. Rather than keeping the focus on the sponsors, we suggest that much might be learned by examining the types of success generated by different combinations of industry conditions, forms of R&D partnerships and internal operations (e.g. leadership, emergent culture and human resource composition).

It is abundantly clear from all of the figures in this paper, that since 1960 the pattern of newly established R&D partnerships has been non-linear in terms of numbers, forms, sectors, and locations. It is also clear that there seems to be no clear-cut evolutionary pattern yielding stability. The pattern of these dynamics suggest that researchers might consider going beyond the current additive, linear cost/benefit and firm specific logic.

In their analysis of SEMATECH, Browning, Beyer and Shetler (1995) suggested that the balance between cooperation and competition in highly dynamic industries is quite delicate. It can dynamically shift with extreme accelerations yielding the dominance of new patterns. In the case of SEMATECH their complexity theory analysis suggest a dramatic shift to cooperation. We propose that in the future there should be more dynamic longitudinal analyses of R&D partnership formations and success using notions from complexity theory to better understand the dynamic character of newly emerging forms.

Box 21.1: Potential topics for future research

Theme one: Knowing more about alliances and networks as cooperative systems?

What is the evolutionary nature of alliance performance?

For example:

Is there a set of common performance dimensions or are most unique to a single alliance?

Is the definition of performance for alliance expanding?

Can a single alliance promote learning, reduce transactions costs, cut production

costs, promote strategic accomplishment for the sponsors and survive?

What types of alliances can provide specific types of performance superior to that of the corporate form?

Can alliances provide a permanently temporary template for specific types of accomplishment?

How is a discrepancy between the initial expectations of sponsors and alliance outcomes treated within each sponsor and within the alliance?

How is the concept of alliance performance related to the notion of a competitive network based on cooperation?

What internal dynamics within the alliance are related to its performance?

For example:

Does the purpose and strategy of the alliance evolve with the time, the setting or other factors such as the tactics of the sponsors?

What is the effective management philosophy/governance system for different types of alliances and does this alter the governance of the sponsors ?

How important is the leadership of the alliance for its success and survival?

Are there economies of scale and/or limits to scale in different types of alliances?

Are alliances a good place to work, grow and live?

What new types of alliances are being formed and what types of performance do they provide?

What is the role of individual and professional connections in alliance/network formation and performance?

What configuration of human resources is related to different aspects of performance?

What are the dynamics of alliance and network evolution within and across settings?

For example:

Are there long-term paths of alliance and network formation that move systematically within specific sectors/nations and from one sector/nation to the next?

Are there cultural factors underlying alliance and network formation and/or are alliances becoming such a dominant form that they are altering business culture?

Can nations place themselves in a competitive advantage/disadvantage by expanding/limiting alliance formations and operations?

Are international and global networks restricted to specific sectors and if so why?

Are alliances /networks in some sectors a transition stage to the evolution of other forms?

At what point, if any, do alliances/networks become the dominant form?

Theme Two: Development of new integrated theories

What factors delineate the boundaries of the current theoretical perspectives and yield higher-order concepts for integrating the current views?

For example:

What is the relative role of economic efficiency, power/control, legitimacy, and innovation/exploration in alliance and network formation and operation?

What are the boundaries of the current theories and where are they most applicable?

What is the relative contribution of and what types of contributions by sponsors, alliances and networks to the success of an industry?

What initial factors and conditions are associated with the rapid rise of new alliance forms and network configurations?

What is the pattern of alliance adoption over time and how does it vary by industry?

What, if any, are the stable patterns of alliance operations in specific settings (industry, nation, collections of nations).

What concepts can be drawn from heretofore neglected business disciplines (accounting, finance) and perspectives to help explain and predict alliance formation and performance?

For example:

Is the pattern of alliance and network formations consistent with complexity theory?

Do specific patterns of alliance and network formation signal a sector at the edge of chaos?

Can small initial alterations in alliance forms and/or network characteristics yield fundamental shifts in the pattern of alliance/network development?

To what extent are alliance/network formations reflective of the political desires of senior officers in the sponsors for greater individual power and/or legitimacy?

To what extent does the development of alliances with competitors represent a new form of collusion and oligopoly?

To what extent are alliance/network formation altered by specific governmental policies (R&D tax policy) and philosophies?

To what extent do alliances and networks allow firms to circumvent accounting provisions, tax laws, immigration constraints and related factors?

Theme Three: Associations among alliances and networks

What is the dynamic relationships among alliances and networks?

For example:

Do different types of alliances more heavily populate different types of networks?

To what extent does the formation of new formal alliances facilitate or frustrate the development of specific types of networks among firms?

To what extent does the establishment of "weak ties" lead to the subsequent development of alliances?

To what extent do firms in the center of networks also need to develop formal alliances to maintain influence over the network?

To what extent are cooperative systems composed of national and multinational sponsors layered on top of traditional firms?

What types of networks spawn the development of new alliance forms?

For example:

What is the association between important network dimensions and newly important aspects of alliances?

Do different types of networks force some members to establish specific types of alliances?

At what point does the proliferation of a specific type of alliance lead to a specific type of network.

What types of alliances and networks are associated with specific managerial philosophies?

For example:

Are alliances and networks subject to inertia due to the managerial philosophy in the executive suites of sponsoring firms?

Can alliances shift form and function as the expectations of sponsors shift?

To what extent does extensive experience with alliances and networks shift the managerial philosophy for the running the sponsoring firms?

At what point, if any, does the traditional managerial philosophy stressing competition negative the cooperative thrust of alliances and networks?

If the dynamic patterns revealed here continue in the future, we see whole industry sectors being dominated by cooperative systems layered on top of traditional firms in much the same manner multinationals are layered on top of purely domestic firms. Yet we also know the lesson of this analysis. New forms unanticipated at this time will emerge and our theory will follow this emergence to the degree we can forget as well as learn.

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Appendix 21.1: The MERIT-CATI Database

The CATI data bank is a relational database which contains separate data files that can be linked to each other and provide both dis-aggregated and combined information from several files. So far information on thousands of technology-related interfirm partnerships has been collected for the period 1960–1998. Systematic collection of interfirm partnerships started in 1987. Many sources from earlier years are consulted to establish a retrospective view. In order to collect information on interfirm alliances various sources are consulted: newspaper and journal articles, books dealing with the subject, and in particular specialized journals which report on business events. Company annual reports, the *Financial Times Industrial Companies Yearbooks* and Dun and Bradstreet's *Who Owns Whom* provide information about dissolved equity ventures and

investments, as well as ventures that were not registered when surveying alliances.

The data bank contains information on each agreement and some information on companies participating in these agreements. The first entity is the interfirm cooperative agreement. Cooperative agreements are defined as common interests between independent (industrial) partners which are not connected through (majority) ownership. In the CATI database only those interfirm agreements are being collected that contain some arrangements for transferring technology or joint research. Joint research pacts and second-sourcing are clear-cut examples. Information is also collected on joint ventures in which new technology is received from at least one of the partners, or joint ventures having some R&D program. Mere production or marketing joint ventures are excluded. In other words, this material is primarily related to R&D collaboration and technology cooperation, i.e., those agreements for which a combined innovative activity or an exchange of technology is at least part of the agreement.